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EXAMINER	
HUGHES, KEVIN G	

ART UNIT	PAPER NUMBER
2193	

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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

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Office Action Summary	Application No.	Applicant(s)
	10/582,298	PAPAGEORGIOU ET AL.
	Examiner	Art Unit
	KEVIN G. HUGHES	2193

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *12 June 2006*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-20* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-20* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *12 June 2006* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)	4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)	5) ☐ Notice of Informal Patent Application
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *attached*.	6) ☐ Other: _____.

DETAILED ACTION

Claim Objections

Claims 2, 9, and 12 objected to because of the following informalities: As per claims 2 and 9, appending qubits to registers should be appending qubits to the approximation or eigenvector as the applicant does not mean to claim changing the structure of the quantum computer registers, but rather appending qubits to the end of a value stored in the register. As per claim 12, 'the qubit register' should read 'the quantum computer register' or 'the register'. Appropriate correction is required.

Claim Rejections - 35 USC § 101

35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

Claims 1, 4 rejected under 35 U.S.C. 101 because they recite methods for preparing states of a quantum computer without recitation of a particular machine, physical transformation of a physical or tangible object and include factors weighing against eligibility such as claims are directed to the mere recitation of a general concept.

Claim Rejections - 35 USC § 112

The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Claims 8, 12-13, and 20 recite the limitation "the ... Abrams and Lloyd quantum method". Claim 20 recites “a module stored on magnetic media”. There is insufficient antecedent basis for these limitations in the claims.

Claims 12-13 and 20 provide for the use of an eigenvector in the Abrams and Lloyd quantum method but, since the claim does not set forth any steps involved in the method/process, it is unclear what method/process applicant is intending to encompass. A claim is indefinite where it merely recites a use without any active, positive steps delimiting how this use is actually practiced.

The term "classically" in claim 14 is a relative term which renders the claim indefinite. The term is not defined by the claim, the specification does not provide a standard for ascertaining the requisite degree, and one of ordinary skill in the art would not be reasonably apprised of the scope of the invention. While the specification is abundant with references to classic(ally), the degree with which to apply to the term appears to be any known method which is not the instantly claimed method, therefor one cannot reasonably understand what the applicant wishes to patent as their invention.

Claims 2-7, 9, and 15 rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claim 2 recites ‘a method for computing an approximation of a vector’ comprising ‘storing an approximation' and ‘appending a qubit to the register’; it is unclear how storing an approximation and appending a qubit to the register are computing an approximation of a vector. Sufficient detail apparatus or

elements must be recited to adequately describe and constitute the proposed method for computing an approximation of a vector. The claims are incomplete in that they recite only a portion of the methodology required for the method for computing an approximation of a vector to become operational, i.e., they omit essential elements and/or steps. See MPEP 2172.01. As per claim 3, it is unclear how ‘performing the Hadamard transformation of a qubit’ are computing an approximation. As per claim 4, it is unclear how the 'preparing the initial state of a quantum computer' comprises 'preparing the initial state of a quantum computer' as a step, further, it is unclear what the Hadamard transformation is being applied to and how performing a Hadamard transformation prepares an initial state. As per claim 5, it is unclear what vector is stored and how appending two qubits to the vector prepare an initial state. As per claims 6 and 7, it is unclear how the state ‘ket 0‘ and performing a Hadamard transformation on the qubit of state ‘ket 0’ prepares an initial state of a quantum computer. As per claim 9 and 15 it is unclear how appending two qubits to an eigenvector and taking the Hadamard transformation of the qubits results in an eigenvalue.

Claim 20 recites “a module stored on magnetic media”. It is unclear what a module stored on magnetic media has to do with a quantum computing system or how it is to be used. Therefor claim 20 will not be treated on the merits.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 1-10 and 13-18 rejected under 35 U.S.C. 102(b) as being anticipated by “How Behavior of Systems with Sparse Spectrum can be Predicted on a Quantum Computer” by Ozhigov.

As per claim 1, Ozhigov discloses a method for preparing a quantum state as an input to a quantum computer computation, said method comprising: preparing a quantum state as an input to a quantum computer computation, wherein said preparing a quantum state includes performing a Hadamard transformation on at least one qubit (Page 676, column 1 lines 25-30, performing the Hadamard transformation on at least one qubit).

As per claim 2, Ozhigov discloses a method for computing an approximation of a vector, comprising: storing a first approximation in a quantum computer register; and appending a qubit to the register (Page 676, column 1 lines 25-30 and column 2 lines 6-7, x is a first approximation stored in a register, ‘a’ is a qubit appended to x).

As per claim 3, Ozhigov discloses the method as recited in claim 2, further comprising: performing a Hadamard transformation on the appended qubit (Page 676, column 1 lines 25-30, performing the Hadamard transformation on at least one qubit).

As per claim 4, Ozhigov discloses a method for preparing the initial state of a quantum computer, comprising: preparing the initial state of a quantum computer, wherein said preparation includes performing a Hadamard transformation (Page 676, column 1 lines 25-30, performing the Hadamard transformation on at least one qubit).

As per claim 5, Ozhigov discloses the method as recited in claim 4, wherein said preparation further includes: storing a vector in a quantum computer register; and appending at least two qubits to the vector (Page 676, column 1 lines 25-30 and column 2 lines 6-7, x is a vector stored in a register, 'a' is at least two qubits appended to x).

As per claim 6, Ozhigov discloses the method as recited in claim 5, wherein: at least two of the appended qubits are in the state |0> (Page 676, column 2 lines 7-8, 'a' is is initialized to zero state [see also column 2 lines 24-26]).

As per claim 7, Ozhigov discloses the method as recited in claim 6, wherein: the Hadamard transformation is performed on the appended qubits (Page 676, column 1 lines 25-30, hadamard transformation applied on 'a').

As per claim 8, Ozhigov discloses a method for efficiently preparing the initial state of a quantum computer required by the quantum method for eigenvalue approximation of Abrams and Lloyd, said method comprising the steps of: storing a first eigenvector approximation in a quantum computer register; appending at least two

qubits in the state |0> to the first eigenvector approximation (Page 676, column 2 lines 7-8, ‘a’ is is initialized to zero state [see also column 2 lines 24-26]); and performing a Hadamard transformation on the appended qubits (Page 676, column 1 lines 25-30 and column 2 lines 6-7, x is a first approximation stored in a register, ‘a’ is at least two qubit appended to x, Hadamard transformation is applied to ‘a’).

As per claim 9, Ozhigov discloses a method for efficiently preparing an initial state of a quantum computer for eigenvalue approximation, comprising: obtaining a first eigenvector; placing the eigenvector in a quantum computer register; appending at least two qubits to the register; and performing a Hadamard transformation on each of the at least two qubits (Page 676, column 1 lines 25-30 and column 2 lines 6-7, x is a first approximation stored in a register, ‘a’ is at least two qubit appended to x, Hadamard transformation is applied to ‘a’).

As per claim 10, Ozhigov discloses the method as recited in claim 9, wherein the at least two qubits are in the state |0> (Page 676, column 2 lines 7-8, ‘a’ is is initialized to zero state [see also column 2 lines 24-26]).

As per claim 13, Ozhigov discloses a method for approximating an eigenvalue of an eigenproblem with a quantum computer, comprising: obtaining a first eigenvector from a course discretization of the eigenproblem; storing the first eigenvector in a quantum register of size log N.sub.0 qubits (Page 676 line 1, length of register is log M

qubits); appending at least two qubits in a second quantum register to the first eigenvector, wherein the at least two qubits are in the state |0> (Page 676, column 2 lines 7-8, ‘a’ is is initialized to zero state [see also column 2 lines 24-26]); performing a Hadamard transformation on each of the at least two qubits to derive a second eigenvector; and using the second eigenvector in the Abrams and Lloyd quantum method (Page 676, column 1 lines 25-30 and column 2 lines 6-7, x is a first approximation stored in a register, ‘a’ is at least two qubit appended to x, Hadamard transformation is applied to ‘a’).

As per claim 14, Ozhigov discloses the method as recited in claim 13, wherein the first eigenvector is obtained classically (Inherent, eigenvector is obtained from a classic approximation).

As per claim 15, Ozhigov discloses a quantum computing system for computing an eigenvalue, comprising: means for storing a first eigenvector in a quantum register; means for appending at least two qubits to the first eigenvector in the quantum register; and means for performing a Hadamard transformation on each of the at least two qubits (Page 676, column 1 lines 25-30 and column 2 lines 6-7, x is a first approximation stored in a register, ‘a’ is at least two qubit appended to x, Hadamard transformation is applied to ‘a’).

As per claim 16, Ozhigov discloses the quantum computing system as recited in claim 15, wherein said additional qubits are appended while in a predetermined state (Page 676, column 2 lines 7-8, 'a' is is initialized to zero state [see also column 2 lines 24-26]).

As per claim 17, Ozhigov discloses a quantum computing system as recited in claim 16, wherein the predetermined state is the state |0> (Page 676, column 2 lines 7-8, 'a' is is initialized to zero state [see also column 2 lines 24-26]).

As per claim 18, Ozhigov discloses a quantum computing system, comprising: a first quantum register with size of at least log N.sub.0 qubits (Page 676 line 1, length of register is log M qubits), able to store an eigenvector; means for appending at least two qubits in a second quantum register, each of the at least two qubits in the state |0> (Page 676, column 2 lines 7-8, 'a' is is initialized to zero state [see also column 2 lines 24-26]), to the eigenvector; and means for performing a Hadamard transformation on each of the at least two qubits (Page 676, column 1 lines 25-30 and column 2 lines 6-7, x is a first approximation stored in a register, 'a' is at least two qubit appended to x, Hadamard transformation is applied to 'a').

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 11-12 and 19-20 rejected under 35 U.S.C. 103(a) as being unpatentable over Ozhigov in view of "A Two-grid Discretization Scheme for Eigenvalue Problems" by Xu et al. (hereinafter Xu).

As per claim 11, Ozhigov fails to disclose the method as recited in claim 10, wherein said first eigenvector approximation is obtained for an eigenproblem discretized on a coarse grid.

Xu discloses wherein said first eigenvector approximation is obtained for an eigenproblem discretized on a coarse grid (Abstract).

Ozhigov and Xu are analogous art in the field of generating eigenvalue approximations.

It would have been obvious to one of ordinary skill in the art at the time of the invention to implement the two-grid discretization scheme for determining eigenvalues as disclosed by Xu because it would allow for the eigenvalue approximation to generated with asymptotically optimal accuracy (quickly and accurately) and reduces the eigenvalue problem complexity (XU, Abstract and Introduction lines 11-17).

As per claim 12, Ozhigov discloses the method as recited in claim 11, further comprising using the qubit register after the Hadamard transformation as input to the

Abrams and Lloyd quantum method (Page 675 column 2 line 3-4 and Page 676 column 2 lines 22-23, Abrams and Lloyd proposed the quantum method applied).

As per claim 19, Ozhigov fails to disclose the quantum computing system as recited in claim 18, wherein: the eigenvector is derived from an eigenproblem discretized on a coarse grid.

Xu discloses wherein said first eigenvector approximation is obtained for an eigenproblem discretized on a coarse grid (Abstract).

Ozhigov and Xu are analogous art in the field of generating eigenvalue approximations.

It would have been obvious to one of ordinary skill in the art at the time of the invention to implement the two-grid discretization scheme for determining eigenvalues as disclosed by Xu because it would allow for the eigenvalue approximation to generated with asymptotically optimal accuracy (quickly and accurately) and reduces the eigenvalue problem complexity (XU, Abstract and Introduction lines 11-17).

As per claim 20, Ozhigov discloses the quantum computing system as recited in claim 19, further comprising: means to use the eigenvector as input to the Abrams and Lloyd quantum method (Page 675 column 2 line 3-4 and Page 676 column 2 lines 22-23, Abrams and Lloyd proposed the quantum method applied); and a module stored on magnetic media (Inherent, quantum computers implementing these methods have modules stored on media to direct computer operations).

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to KEVIN G. HUGHES whose telephone number is (571)270-3365. The examiner can normally be reached on M-Th/F 9-5.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Lewis Bullock can be reached on 5712723759. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/KEVIN G HUGHES/
Examiner, Art Unit 2193

/Tan V Mai/
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